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Abstract

In this paper, we review the evidence for job polarization in the U.S. and provide a description of the occupational employment changes that characterized the U.S. labor market during the 1970s, 1980s, and 1990s. We begin by replicating the existing job polarization trends, which are produced using a modified occupational coding scheme intended to make occupational categories comparable over time. Using two alternative procedures to obtain consistent occupational codes across decades, we show that the finding that jobs polarized in the 1990s relative to the 1980s no longer holds. Instead, we find that occupational employment shifts were very similar during the two decades. In addition, we demonstrate that the method used to rank occupations according to their skill content has a substantial impact on the employment growth in low-skill job categories. Finally, using an additional occupational crosswalk that allows us to obtain consistent occupational categories from 1970 to 2002, we provide evidence in favor of a long-term trend towards employment growth in high-skill jobs and employment decline in some middle-skill jobs, but no sharp contrast between the 1980s and the 1990s. Our findings suggest that the evolution of the occupational employment structure and the divergent wage growth patterns observed during the 1980s and 1990s do not easily fit within the routinization story as usually told.

Keywords

Job Polarization, Occupational Employment, Employment Growth, Wage Inequality

JEL Classification

J21, J31

1 Introduction

A number of recent papers show that over the last two decades, employment growth in the U.S. and other advanced economies has been characterized by a marked pattern of job polarization (for a review, see Acemoglu and Autor (2010)). Job polarization occurs when the employment shares accounted for by high-skill and low-skill jobs grow faster than the employment share accounted for by middle-skill jobs. The most widely used explanation for this employment growth pattern is a nuanced version of skill-biased technological change based on the "routinization" model developed by Autor, Levy, and Murnane (2003).

Interest in job polarization often stems from its presumed connection to wage inequality. Indeed, the first studies that document the job polarization trends also examine the accompanying wage growth trends to determine whether they follow a similar pattern (see Autor, Katz, and Kearney (2006, 2008); Goos and Manning (2007); Dustmann, Ludsteck, and Schoenberg (2009)). For the U.S., Autor, Katz, and Kearney (2006, 2008) find that both the changes in the wage structure and the changes in the employment structure followed a monotone growth pattern during the 1980s and a polarized growth pattern during the 1990s. Based on this evidence, they argue that technological change has played a central role in the reshaping of the U.S. wage structure because computer technology reduces the demand for "traditional middle-class jobs" (Goldin and Katz (2008)). This has been an influential finding in the literature since several researchers have interpreted the slowdown in wage inequality growth in the 1990s as a challenge to demand side explanations for expanding wage inequality, such as skill-biased technological change (see, for example, Card and DiNardo (2002); Lemieux (2006)).[1]

Despite recent evidence of employment polarization in the U.S., the existing literature is nevertheless unclear about the timing of this phenomenon. While more recent papers suggest that U.S. job polarization started in the 1990s, several earlier papers showed that this trend was already unfolding in the 1980s (see, for example, Juhn and Murphy (1995); Acemoglu (1999); Juhn (1999)). Since the timing of job polarization is important to understanding labor market developments, including the evolution of the wage structure, this issue deserves further attention.

The purpose of this paper is to reexamine the changes in the U.S. employment structure during the 1970s, 1980s, and 1990s. Our main finding is that the recently documented patterns of U.S. job polarization in the 1990s relative to the 1980s are based on a modified occupational coding scheme that leads to systematic occupational mismatch. When we address this problem, we find that there has been a long-term trend towards employment growth in high-skill jobs and employment decline in some middle-skill

[1] In fact, several earlier papers argue that the "shrinking middle" and, in particular, the decline in manufacturing employment are major sources of the *increase* in lower tail inequality during the 1980s (Bluestone and Harrison (1988); Borjas and Ramey (1995); Juhn (1999)).

jobs, with no major differences between the 1980s and the 1990s. Our evidence suggests that current explanations for the changes in the patterns of wage inequality between the 1980s and the 1990s that are based on changes in the occupational employment structure should be reexamined. The next section discusses several methodological issues related to the measurement of the changes in the distribution of employment, Section 3 describes the data that will be used in the analysis, Section 4 reassesses the empirical evidence in light of the methodological issues previously discussed, and Section 5 concludes.

2 Background and Methodological Issues

There are numerous studies that measure changes in the relative demand for skills by means of changes in the distribution of jobs. However, while in the earlier literature jobs are typically represented by industry-occupation cells (see, for example, Katz and Murphy (1992)), in the more recent studies they are defined exclusively by occupations. One reason for this change is the "routinization" model developed by Autor, Levy, and Murnane (2003), which relates computer technology to the types of tasks that workers perform at their jobs. Job tasks are less likely to vary across industries once occupational differences are taken into account. This model is based on the idea that computer capital is a close substitute for workers performing routine tasks and a complement to workers performing non-routine abstract tasks. Under the assumption that routine tasks are concentrated in middle-skill jobs and non-routine abstract tasks in high-skill jobs, the model predicts that a fall in the price of computer capital will lead to a decrease in the employment share accounted for by middle-skill jobs, and an increase in the employment share accounted for by high-skill jobs.[2] Since this paper is concerned with a reassessment of the evidence for job polarization, we adopt the approach of defining jobs by occupations.

The body of literature on job polarization largely follows Goos and Manning (2007), who identify shifts in the relative demand for skills by ranking occupations based on some measure of occupational skill content, and examining changes in the shares of employment accounted for by different occupational skill groups. Goos and Manning (2007) and Dustmann, Ludsteck, and Schoenberg (2009) measure the skill content of occupations by the occupational median wage, Autor and Dorn (2009, 2010), Goos, Manning, and Salomons (2009), and Acemoglu and Autor (2010) by the occupational mean wage, and Autor, Katz, and Kearney (2006, 2008) by aver-

[2]Another reason for the focus on occupations is that the industrial composition changes that took place during the 1990s played a less important role in the observed polarization of the employment structure. Recent results from a shift-share decomposition analysis conducted by Acemoglu and Autor (2010) indicate that most of the post-1980 changes in the distribution of employment can be explained by within-industry employment shifts away from routine-intensive occupations.

age years of education in each occupation. In all cases, the exercise is to rank occupations based on the chosen skill content measure in a base year, and then see how the distribution of employment changes across different percentiles of the occupational employment distribution. Middle-skill jobs correspond to occupations with average years of schooling (or mean/median wages) close to the median of the occupation-specific distribution of schooling (or wages). In our empirical work, we follow this approach and use both skill content measures to rank occupations.

A major issue in examining changes in the distribution of employment across occupations is having consistent occupational categories over time. In the U.S., however, the occupational classification system used to categorize jobs into specific occupations is periodically revised to better reflect the world of work. When these revisions are substantial, a one-to-one mapping between the occupational categories of the new system and those of its predecessor becomes problematic. One such major revision occurred when the 1980 Standard Occupational Classification System was replaced by the 2000 Standard Occupational Classification (SOC) System. Since the 1980 and 2000 SOCs were used to develop the 1980, 1990, and 2000 Census occupational classification systems, which, in turn, were adopted by most wage and employment surveys, this revision created an important break in the time series for occupational data between 1990 and 2000. The key difference between the 1980 and the 2000 SOCs is the rearrangement of the classification system using the concept of "job families" (for more information, see Scopp (2003)). The main objective was to place people who worked together in the same occupational groups, regardless of their skill levels. As a result of this revision, many detailed occupational categories and parts of these categories shifted between the 1990 and 2000 Census occupational classification systems, which led to a "movement" of workers from one occupational category to another due to a classification change rather than a real change in the workforce. Some of the major differences between the 1990 and 2000 Census data that are particularly important in the context of the job polarization literature are an increase in management and service-related occupations, and a decrease in clerical, maintenance, and production occupations.

In order to overcome this limitation, several U.S. studies have relied on an occupational coding scheme developed by Meyer and Osborne (2005), which is designed to make occupations in each Census year comparable to the 1990 Census. The occupational categories of this scheme were created by aggregating the original 504 detailed categories used in the 1990 Census data into 389 broader categories, which were then mapped to the original 509 detailed categories used in the 2000 Census data. Although the use of more aggregate occupational categories makes the mapping between the two Census occupational classification systems more reliable, the problem is not completely eliminated since many of the detailed categories used in the Census 2000 data cannot be precisely mapped to the broader categories of the new system. As we demonstrate below, this modified occupational

coding scheme has several drawbacks that make occupational employment comparisons between the 1990 and 2000 Censuses unreliable.

A main objective of this paper is to examine changes in the U.S. occupational employment structure across decades using an alternative to the Meyer and Osborne (2005) occupational coding scheme. We propose two new complementary approaches. The first approach will use the 1990 and 2000 Census data and will bridge the two occupational classification systems using the original U.S. Census Bureau occupational crosswalk (for details, see Scopp (2003)). This crosswalk is based on a "double-coded" sample and shows the redistribution of each 1990 occupational category into various 2000 occupational categories. In other words, it provides information on the proportions of workers that moved across different categories. Since the analysis of job polarization trends does not require individual-level data, these proportions can be used as weights in the 1990 Census data to determine the 1990 distribution of employment across 2000 occupational categories. The second approach will use the 1990 Census data in combination with 1999-2002 data from the March Supplement of the Current Population Survey (March CPS).

3 Data and Samples

The empirical analysis in this paper is based on two data sources: the Census data for the years 1970, 1980, 1990, and 2000, and the March CPS data for the years 1971 to 2002. The Census data come from IPUMS-USA (Ruggles, Sobek, Alexander, Fitch, Goeken, Hall, King, and Ronnander (2008)) and include labor force and demographic information for 1 percent of the U.S. population in 1970, and 5 percent thereof in each of the remaining three years. The main advantage of the Census data is to be found in the large sample sizes, which are necessary for an analysis of employment changes within detailed occupational categories. We obtain the March CPS data from IPUMS-CPS (King, Ruggles, Alexander, Flood, Genadek, Schroeder, Trampe, and Vick (2010)) and extract a sample that is comparable to our Census extracts. The main advantage of the March CPS is that it uses the 1990 Census occupational classification system until 2002, and so it allows examining the 1990-2000 changes in the distribution of occupational employment using the same classification system. For both data sources, only individuals with ages between 18 and 65, employed in the civilian labor force at the time of the survey, not living in group quarters, and not performing unpaid family work are used in the analysis. More details on the processing of the data and the construction of the samples can be found in Appendix A.

4 Empirical Findings

4.1 Reassessing the Evidence for Job Polarization

The most widely cited evidence for the polarization of the employment structure in the U.S. is given by a figure that first appeared in Autor, Katz, and Kearney (2006), and was later used by Autor, Katz, and Kearney (2008) to show that the occupational employment growth was monotone in skill during the 1980s and polarized during the 1990s. The figure is constructed by ranking occupations based on some measure of skill in 1980, grouping the ranked occupations into percentiles of employment, and then plotting the smoothed percentage changes in employment in each of the resulting skill percentiles for the 1980s and 1990s. In the top left panel of Figure 1, we replicate the figure in Autor, Katz, and Kearney (2008) using U.S. Census data extracted to be comparable to those used in their study. In this figure, we rank occupations based on their average years of education, and use the Meyer and Osborne (2005) occupational coding scheme to bridge the 1990 and 2000 Census occupational classification systems. As can be seen, during the 1990s, the changes in the shares of employment accounted for by different occupational skill groups follow a U-shaped pattern, implying that jobs have indeed polarized during this decade.

The purpose of this section is to highlight the sensitivity of this finding to the method used to deal with the occupational coding changes in the U.S. Census. This is of particular concern when making comparisons between the 1980s and the 1990s, since the occupational classification system was completely revised for the 2000 Census. As a result of this revision, there is considerably more noise when estimating employment changes for very detailed occupational categories in the 1990s compared to the 1980s. We argue that this noise, as well as the presence of significant outlying observations, has a dramatic impact on the shape of the smoothed changes in occupational employment shares.

The top right panel of Figure 1 shows the same smoothed estimates as in the top left panel together with the raw data behind them. It is important to note when interpreting the top right panel that the smoothed lines are the exact same ones as those reported in the top left panel, and that the only difference between the two figures is the scale of the y-axis. An important finding revealed by the plot of the raw data is that the 1990s have several extreme observations. In fact, the standard deviation of the percentile employment changes is nearly twice as large in the 1990s compared to the 1980s (0.37 compared to 0.23). These outlying observations have a considerable impact on the overall shape of the smoothed curve in the 1990s, and whether they represent actual percentile employment changes or other factors, such as coding error, is crucial to the interpretation of the observed U-shaped pattern of employment growth. A close inspection of the percentage change in occupational employment during the 1990s, which we document in Appendix B, reveals two sources of error: the first is the result

of several problematic coding choices, and the second is related to the systematic occupational mismatch inherent in the occupational coding scheme developed by Meyer and Osborne (2005). The problem with this occupational coding scheme lies in the way in which the new occupational codes are constructed. An individual in the 2000 Census is assigned a unique occupation in the 1990 Census occupational classification system based on the most likely occupation given by the original U.S. Census Bureau occupational crosswalk. In some cases, this procedure produces one-to-one matches; in many others, however, some 2000 Census occupations end up being split across many 1990 Census occupational categories. In these latter cases, assigning a single 1990 Census occupation to individuals in the 2000 Census can result in substantial occupational mismatch.

We assess the sensitivity of the documented pattern of occupational employment growth to the Meyer and Osborne (2005) occupational coding scheme in two ways. First, since the figure is produced with data aggregated at the occupation level, we argue that there is no need to assign each worker in one Census year a unique occupation from the occupational classification system used in the other Census year. Instead, we can use the original U.S. Census Bureau occupational crosswalk directly to assign fractions of workers in each occupation in the 1990 Census to 2000 Census occupational categories.[3] This crosswalk is constructed by recoding a sample of workers from each occupation in the 1990 Census using the 2000 Census occupational classification system, and gives the proportion of each 1990 occupational category belonging to each 2000 occupational category. Using these conversion factors, we assign proportions of workers in 1990 to 2000 occupational categories. Of course, we must also perform a similar conversion of the 1980 Census data. Crosswalks are not available for 1980 to 2000 conversions. However, since there were only minimal changes between the 1980 and 1990 Census occupational classification systems (all of which allow for a one-to-one mapping between the occupational categories of two systems), we use the same conversion factors from the 1990 to 2000 crosswalk. Second, as a robustness check, we also examine the same occupational employment growth trends using 1999-2002 March CPS data instead of 2000 Census data. The 1990 Census occupational classification system was used in the CPS data from 1991 to 2002. Therefore, by combining Census and CPS data, we are able to obtain consistent occupational codes from 1980 to 2002.

We report results from these exercises in the bottom panels of Figure 1. As can be seen, the two alternative procedures used to obtain consistent occupational codes lead to similar findings and do not reproduce the U-shaped pattern of occupational employment growth reported in the top

[3]The crosswalk provided by the U.S. Census Bureau is designed to convert the 1990 occupational codes into the 2000 occupational classification system. It is also possible, but not recommended, to use this crosswalk to convert the 2000 occupational codes into the 1990 occupational classification system. When we do this, the results are nearly identical.

left panel of Figure 1.[4] When we use the U.S. Census Bureau crosswalk, the standard deviation of the percentile employment changes in the 1990s falls from 0.37 to 0.23 (thus becoming the same as in the 1980s), and when we use the 1999-2002 March CPS data, it falls to 0.26. In Appendix C, we report results using the same procedures, but ranking occupations by their mean log wage in 1980.[5] Based on these findings, we conclude that the divergent pattern of occupational employment growth observed during the 1990s, which is commonly referred to as job polarization, is largely the result of smoothing over extreme occupational employment changes that are mainly due to the revision of the occupational classification system prior to the 2000 Census.

4.2 Measuring the Skill Content of Occupations

In this section, we assess the sensitivity of the changes in occupational employment to the skill content measure used to rank occupations. Much of the literature ranks occupations based on a measure of education or wages, usually without formal justification. Our results so far indicate that the shape of the overall pattern of occupational employment growth varies considerably with the method used to rank occupations, particularly for occupations at the bottom of the skill distribution. For example, the smoothed percentage changes in occupational employment obtained by combining Census and March CPS data reveal more employment growth at the bottom of the occupational skill distribution when occupations are ranked by their mean log wage instead of their average years of education (see Appendix C and the bottom right panel of Figure 1). However, a clear interpretation of this difference is complicated by the fact that the smoothing procedure used to produce the overall pattern of changes is very sensitive to outlying observations. To avoid this issue, we group occupations into skill deciles using either average years of education or mean log wage within occupations in 1980, and plot the unsmoothed percentage changes in employment in each of the resulting occupational skill deciles.

The top panels of Figure 2 show the changes in the occupational employment structure during the 1980s (left panel) and 1990s (right panel) when occupations are ranked by their mean log wage in 1980. Each bar

[4] Plots of the raw data using these alternative procedures are reported in Appendix C.

[5] Appendix C also shows results using an occupational coding scheme developed by IPUMS based on the 1950 Census occupational classification system. While we do not believe that this coding scheme is appropriate for comparisons of occupational employment changes between recent decades, we use it as an additional robustness check and find very similar results to those reported above. The occupational codes included in this scheme are quite aggregated compared to the ones developed by Meyer and Osborne (2005), and therefore may be subject to less mismatch. Interestingly enough, Meyer and Osborne (2005) report that the codes based on the 1950 Census perform similarly to their proposed codes based on the 1990 Census for several measures of consistency over time. In Appendix D of Meyer and Osborne (2005), the codes based on the 1950 Census show less extreme changes in the shares of employment between 1990 and 2000 compared to the codes based on the 1990 Census.

indicates the percentage change in employment in the corresponding occupational skill decile. In the lowest occupational skill group, represented by decile 1, employment growth was very modest in each decade. In contrast, occupational employment fell considerably in skill deciles 2, 3, and 4, and then rose again in skill decile 6, before falling in skill deciles 7 and 8, and finally rising once more in the highest two occupational skill groups. What is notable about these plots is that the pattern of employment growth has more of a "W" shape than the "U" shape that is normally associated with polarization. Nevertheless, employment growth is not monotonic in occupational skill, and therefore is hard to rationalize using a "canonical model" of skill-biased technological change (Acemoglu and Autor (2010)). Another notable feature of these plots is that, broadly speaking, the overall pattern of occupational employment growth is similar in the 1980s and the 1990s.

In the bottom panels of Figure 2, we look at the same occupational employment changes, but rank occupations by their average level of education in 1980. This ranking method is the same as the one used to produce the smoothed changes shown in Figure 1. When occupations are ranked in this way, employment growth is only found at the highest deciles of the occupational skill distribution. Again, the overall pattern of occupational employment changes is similar in the 1980s and the 1990s, with growth being more pronounced in the highest occupational skill group in the 1990s. This latter finding, which is also observed when occupations are ranked by their mean log wage, is consistent with the recently documented convexification of the returns to education (Lemieux (2006); Acemoglu and Autor (2010)). We conclude that the skill content measure used to define the distribution of occupations has a considerable influence on the shape of the overall pattern of occupational employment changes, and, more importantly, on the extent of employment growth in low-skill occupations.[6]

4.3 Examining Longer-Term Changes in the Occupational Employment Structure

A clear understanding of the timing, extent, and nature of the changes in the occupational employment structure is crucial for distinguishing be-

[6]There is nothing in the routinization model developed by Autor, Levy, and Murnane (2003) to suggest that occupations should be ranked by a single observable dimension of skill, such as education, or by a labor market outcome, such as wages. However, it is interesting to note that the model of endogenous job composition developed by Acemoglu (1999) suggests that jobs should be ranked according to residual wages. In this model, the employment structure can become polarized as a result of a shift in the composition of jobs towards high- and low-quality jobs and away from middling jobs. Acemoglu interprets high quality jobs as jobs that pay more for a given set of observable skills, and finds evidence of job polarization starting with the 1980s. When we rank occupations by their mean residual wages, we also find evidence of job polarization in both the 1980s and the 1990s despite the fact that we use a different definition of "jobs". Acemoglu's model of endogenous job composition is one with frictions, and therefore the mechanism behind the changes in the composition of jobs is quite different from competitive stories, such as nuanced versions of skill-biased technological change.

tween potential driving forces and identifying related labor market outcomes. As already mentioned in the introduction of the paper, a leading explanation for the recent evolution of the U.S. wage structure is a nuanced version of skill-biased technological change that caused both wages and employment to follow a monotone growth pattern during the 1980s and a polarized growth pattern during the 1990s (Acemoglu and Autor (2010)). However, the finding that the U.S. occupational employment structure did not polarize until the 1990s is at odds with the conclusions of several earlier U.S. studies, as well as several European studies, that provided evidence that the job polarization trends were already present in the 1980s (see Juhn and Murphy (1995); Acemoglu (1999); Juhn (1999) for the U.S.; Goos and Manning (2007) for the U.K.; and Dustmann, Ludsteck, and Schoenberg (2009) for Germany).

To shed light on this issue, we next examine several changes in the U.S. occupational employment structure in more detail and over a longer time horizon. Specifically, we use 1970 Census data in combination with 1971-2002 March CPS data, and investigate yearly changes in occupational employment for the period between 1970 and 2002. One difficulty with this exercise is that in the 1970 Census and the 1971-1982 March CPS data, occupations are defined based on the 1970 Census occupational classification system, whereas in the 1983-2002 March CPS data, they are defined based on the 1980 and 1990 Census occupational classification systems (which, again, are very similar and allow for a one-to-one mapping between their occupational codes). To obtain consistent occupational categories for the entire period under investigation, we use an earlier occupational crosswalk provided by the U.S. Census Bureau (for details, see U.S. Census Bureau (1989)) and allocate proportions of workers in the 1970 Census occupations to the 1980 Census occupational classification system. Finally, to build on our findings in the previous section and to ensure comparability with the most recent studies, we rank occupations by their mean log wage in the 1980 Census.

Figure 3 shows year-by-year percent changes in employment by occupational skill deciles from 1970 to 2002. The two vertical lines in each panel of the figure are placed on the years when the CPS changed the occupational classification system.[7] The fact that there are no significant trend breaks at these points suggests that the crosswalks are doing a reasonably good job of matching actual occupational employment distributions. There are several interesting long-term trends that can be gleaned from Figure 3. First, employment growth in the highest occupational skill groups (skill deciles 9 and 10) has been visible since at least the beginning of the 1970s, which is consistent with other literature examining longer-term changes in the employment structure (Juhn and Murphy (1995); Juhn (1999)). In addition, there has been a long-term decline in occupational employment in

[7] In 1983, the 1970 Census occupational classification system was replaced with the 1980 Census occupational classification system, and in 1992, the 1980 Census occupational classification system was replaced with the 1990 Census occupational classification system.

skill deciles 2, 4, and 7, and an increase in skill decile 6. In terms of differential shifts in employment between 1980s and the 1990s, only skill decile 5 sees a slight change. Also noticeable is the fact that several skill deciles appear to have employment shifts beginning in the early years and continuing throughout the rest of the period. In particular, skill decile 1 shows a weak, but discontinuous, pattern of employment growth starting with the mid 1970s, and skill deciles 3 and 6 have breaks in their employment change series at the beginning of the 1980s. Overall, there appears to be a long-term trend towards employment growth in high-skill occupations and employment decline in some middle-skill occupations, but no sharp contrast between the 1980s and the 1990s.

Figure 4 takes a different perspective. Instead of showing employment changes at different deciles of the occupational skill distribution, it depicts employment changes in 12 broad occupational categories between 1970 and 2002. The employment shares of these occupational categories are normalized to one in 1970 in order to facilitate comparisons between occupations. As before, there has been a long-term trend in employment growth in high-skill occupations, such as managers and professionals. Furthermore, precision production workers and machine operators have been losing employment shares since at least the beginning of the 1970s. If these occupations represent "routine" jobs in the task-based framework developed by Autor, Levy, and Murnane (2003), then there is evidence that the job polarization trend started long before the 1990s. In summary, this figure provides further evidence that the shifts in the occupational employment structure were very similar in the 1980s and the 1990s, with most of the major trends starting before or during the 1980s.

5 Conclusions

A widely discussed aspect of the recent developments in the U.S. and European labor markets is the polarization of employment between low-skill and high-skill jobs, and its relation to wage inequality. The growing interest in this phenomenon is motivated by demand-side explanations of wage inequality that imply similar growth patterns for employment and wages. Nevertheless, the existing empirical evidence in favor of these explanations is inconclusive. The two leading European studies (Goos and Manning (2007); Dustmann, Ludsteck, and Schoenberg (2009)) found that between 1980 and 2000, both the U.K. and Germany experienced a clear pattern of job polarization, but no wage polarization.[8] In contrast, the U.S. studies (Autor, Katz, and Kearney (2006, 2008)) found that both wages and employment followed a monotone growth pattern during the 1980s and a polarized growth pattern during the 1990s. Therefore, only the U.S. evidence appears to be entirely consistent with the idea that technological

[8]The only exception seems to be the female wage structure in Germany, which polarized during the 1980s (but not during the 1990s).

change has been the driving force behind the evolution of the wage structure over the last two decades of the twentieth century. However, the finding that the U.S. employment structure did not polarize until the 1990s is puzzling if technology is the driving force behind the polarization of work.

The results of our empirical analysis indicate that the U.S. experience may not be as unique as suggested by the existing literature. Previously reported U.S. job polarization trends are produced using a modified occupational coding scheme that is intended to make occupational categories comparable over time, but is susceptible of systematic measurement error. When we address this problem, we find no significant differences in employment growth trends between the 1980s and the 1990s. Furthermore, we show that the overall pattern of changes in the occupational employment distribution is sensitive to the skill content measure used to rank occupations. When occupations are ranked by their average level of education, our findings suggest a roughly S-shaped pattern of employment growth in both decades, with employment losses in low-skill occupations and employment gains in high-skill occupations. However, when occupations are ranked by their mean log wage, a measure similar to the one used in the European studies, our findings suggest a somewhat W-shaped pattern of employment growth in both decades, with employment gains in both low-skill and high-skill occupations and employment losses in some, but not all, middle-skill occupations. This latter pattern appears to be more in line with the European evidence.

Taken together, our findings provide strong evidence in favor of a long-term trend towards employment growth in high-skill jobs and employment decline in some middle-skill jobs, with no major differences between the 1980s and the 1990s. However, the employment changes that we observe at the bottom of the occupational skill distribution, although still similar during the 1980s and the 1990s, are highly sensitive to the method used to rank occupations and thus difficult to interpret. To the extent that the observed shrinking middle-skill jobs are characterized by a relatively high concentration of routine tasks, these results are consistent with the original task-based model developed by Autor, Levy, and Murnane (2003). This model suggests that a fall in the price of computer capital leads to a decrease in the employment shares (and relative wages) of middle-skill, routine jobs, and an increase in the employment shares (and relative wages) of high-skill, non-routine jobs, but has no effect on the employment shares (and relative wages) of low-skill, non-routine jobs. However, the fact that the observed changes in the occupational employment structure are very similar during the 1980s and the 1990s calls into question the contribution of the occupational composition shifts to the changes in the U.S. wage structure over these two decades.

Appendices

A Data

A.1 U.S. Census and American Community Survey

The Census data were obtained with extractions done using the IPUMS system (Ruggles, Sobek, Alexander, Fitch, Goeken, Hall, King, and Ronnander (2008)). The files used are the 1980 5% State (A Sample), 1990 State, 2000 5% Census PUMS, and the 2007 American Community Survey. For 1970, Forms 1 and 2 were used for the Metro sample, and we adjust the weights for the fact that we use two samples. Our extracts contain information on individuals 18 through 65 who are currently employed in the civilian labor force, not living in group quarters or performing unpaid family work. We follow the literature in constructing labor supply weights by multiplying the Census weight by annual hours worked. In 1970, weeks worked last year are only available in categories. We impute a continuous weeks worked last year variable by assigning means of the IPUMS variable `wkswork1` by the categorical variable `wkswork2` by education, gender and race using the 1980 Census. Our measure for hours worked is 'usual hours worked last year' (`uhrswork`). This variable is not available in 1970, and we impute it using 1980 Census information on hours worked last week by gender and race.

For wage calculations, we further restrict the data to those (1) working for wages and salary, (2) with positive income from wages and salary, and (3) with positive weeks worked last year. Top codes differ by Census year. For 1970 and 1980 Census data, we use a top code on wage and salary income of 50,000 and 75,000, respectively. In later Census years, top codes vary by state. We impose a uniform top code of 140,000 in 1990 and 200,000 for the 2000 Census and 2007 ACS. We adjust top coded observations by 1.5. Hourly wages are calculated by dividing annual wage and salary income by annual hours worked, and set to missing hourly wages less than 1 or greater than 100 in 1979 dollars using the CPI-U deflater. We construct weekly wages analogously for those with valid hourly wage observations.

Occupational codes differ by Census year, and we address this in several ways. First, we use a consistent occupation coding scheme developed by Meyer and Osborne (2005), who provide a STATA program here: http://econterms.net/pbmeyer/research/occs/remapjob.do. Closely related occupational codes are provided by IPUMS using variable `occ1990`. We also use occupational categories that are consistent between 1980 and 1990 in the Census and between 1983-2002 in the March CPS. Information on these categories can be found here: http://www.unionstats.com/. Finally, we use U.S. Census Bureau crosswalks to convert aggregated data at the occupational level across Census occupational classification systems. These crosswalks can be found here:

http://www.census.gov/hhes/www/ioindex/tp65_report.html and
http://www.census.gov/hhes/www/ioindex/tp59_report.html.

A.2 March CPS

March CPS data come from IPUMS-CPS (King, Ruggles, Alexander, Flood, Genadek, Schroeder, Trampe, and Vick (2010)). The files used are 1972-2002. Our extracts are meant to be comparable to our Census data and contain information on individuals 18 through 65 who are currently employed in the civilian labor force and not living in group quarters. We construct labor supply weights by multiplying the usual CPS weight with the annual hours worked. We calculate annual hours worked as the product of usual hours worked per week and weeks worked last year for years 1976-2002. For the years 1972-1976, we use hours worked last week and form weeks worked last year from the midpoints of the categorical variable of weeks worked last year.

B Occupational Coding Issues

The following table lists the most problematic occupational categories in the Meyer and Osborne (2005) scheme. In all, just over 28% of the workforce in the 2000 5 percent Census are misallocated using this procedure, where the workforce is defined in the Data Appendix. Generally, Meyer and Osborne (2005) assign to each individual in the 2000 Census an occupation code from the 1990 Census categories using the most likely 'match' according to the Census Bureau's official crosswalks. However, in several instances, the allocated codes are implausible (based on the official conversion factors).

Table B1: Top 15 Misallocated Occupation Codes by Number of Workers

Census 2000 5% Occupation Code	PBM Occupation Code	Mismatch %	Best Code in 1990 Census	Best Match Probability	Correct	Incorrect	Misallocation %
476	275	0.995	274	0.40	14707	2955502	2.4%
485	274	0.959	259	0.82	54217	1272185	1.0%
500	303	0.728	22	0.29	443422	1186752	1.0%
962	889	0.662	889	0.34	540569	1056520	0.9%
1	4	0.970	22	0.93	30911	1011752	0.8%
423	405	0.985	449	0.39	15631	1010317	0.8%
460	468	0.847	466	0.39	178628	985637	0.8%
254	159	1.000	387	0.75	0	835504	0.7%
524	376	0.419	376	0.58	1104237	797799	0.7%
896	779	0.619	779	0.45	478968	779792	0.6%
874	799	0.909	796	0.67	76575	763858	0.6%
102	229	1.000	64	0.60	0	696106	0.6%
822	726	1.000	722	0.48	0	576047	0.5%
562	365	0.530	365	0.47	506928	570694	0.5%
484	274	0.954	257	0.85	26427	545376	0.4%

NOTES: This table lists the top 15 misallocated Census 2000 5% occupation codes by the number of workers misallocated (observations multiplied by Census weight). PMB Occupation Code refers to the occupation codes developed by Meyer and Osborne (2005). Mismatch % refers to the percentage of workers misallocated based on the crosswalk developed by the U.S. Census Bureau. Best Code in 1990 Census refers to the best match based on the Census crosswalk. Correct and Incorrect refer to the numbers of workers allocated correctly and incorrectly, respectively. Misallocation % refers to the percentage of misallocated workers as a fraction of the total work force, as defined in the Data Appendix.

C Robustness and Additional Results

Figure C1: Smoothed Changes in Employment by Occupation, 1980-2000
(Occupations Ranked by Average Years of Schooling)

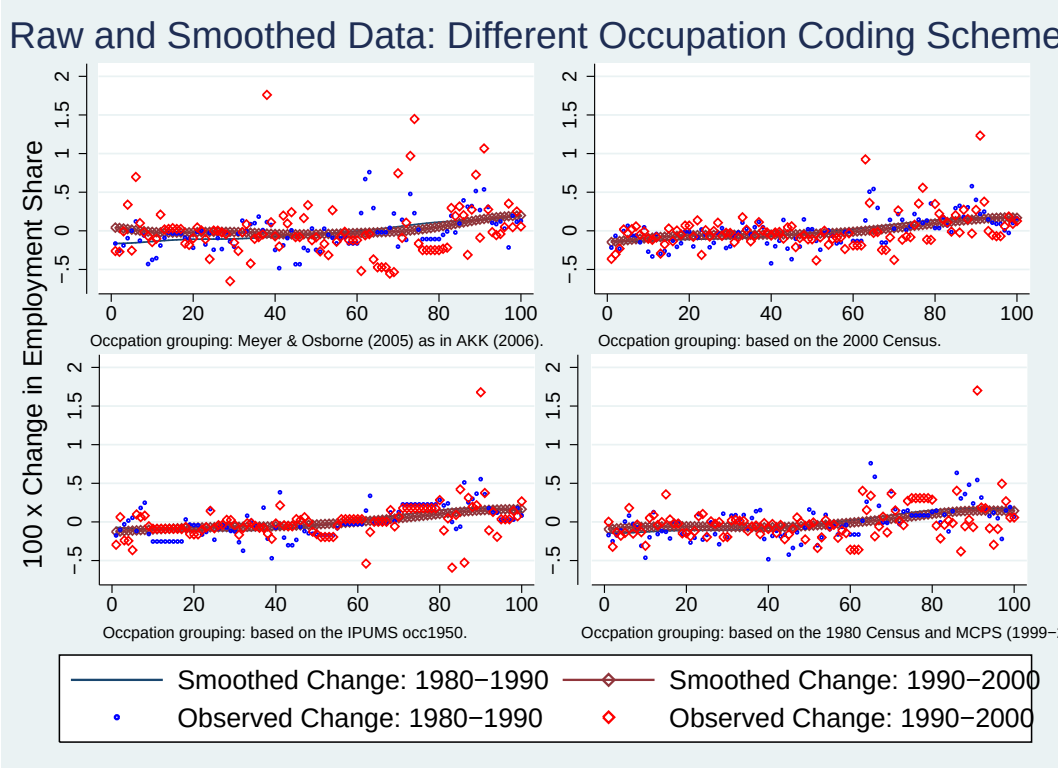
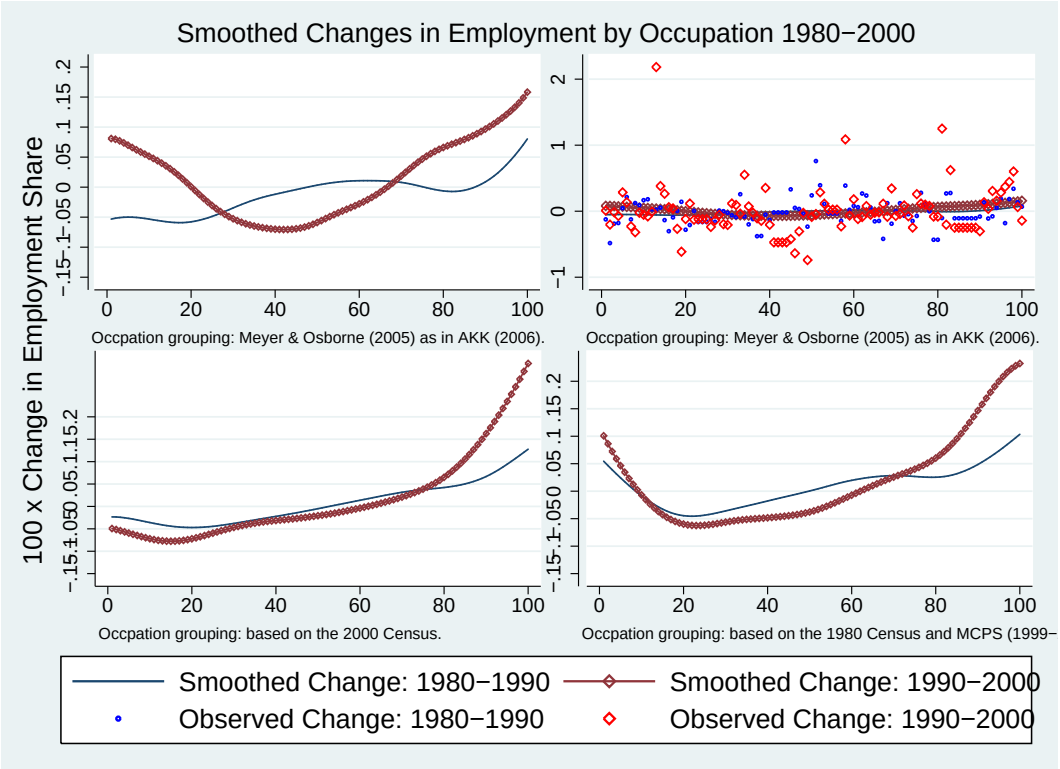


Figure C2: Smoothed Changes in Employment by Occupation, 1980-2000
(Occupations Ranked by Mean Log Wage)



References

ACEMOGLU, D. (1999): "Changes in Unemployment and Wage Inequality: An Alternative Theory and Some Evidence," *The American Economic Review*, 89(5), 1259–1278.

ACEMOGLU, D., AND D. AUTOR (2010): "Skills, Tasks and Technologies: Implications for Employment and Earnings," NBER Working Paper 16082, National Bureau of Economic Research.

AUTOR, D., AND D. DORN (2009): "This Job is "Getting Old": Measuring Changes in Job Opportunities using Occupational Age Structure," *American Economic Review*, 99(2), 45–51.

AUTOR, D. H., AND D. DORN (2010): "The Growth of Low Skill Service Jobs and the Polarization of the U.S. Labor Market," Mit working paper.

AUTOR, D. H., L. F. KATZ, AND M. S. KEARNEY (2006): "The Polarization of the U.S. Labor Market," *American Economic Review*, 96(2), 189–194.

——— (2008): "Trends in U.S. Wage Inequality: Revising the Revisionists," *Review of Economics and Statistics*, 90(2), 300–323.

AUTOR, D. H., F. LEVY, AND R. J. MURNANE (2003): "The Skill Content of Recent Technological Change: An Empirical Exploration," *The Quarterly Journal of Economics*, 118(4), 1279–1333.

BLUESTONE, B., AND B. HARRISON (1988): "The Growth of Low-Wage Employment: 1963-86," *American Economic Review*, 78(2), pp. 124–128.

BORJAS, G. J., AND V. A. RAMEY (1995): "Foreign Competition, Market Power, and Wage Inequality," *Quarterly Journal of Economics*, 110(4), 1075–1110.

CARD, D., AND J. E. DINARDO (2002): "Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles," *Journal of Labor Economics*, 20(4), 733–783.

DUSTMANN, C., J. LUDSTECK, AND U. SCHOENBERG (2009): "Revisiting the German Wage Structure," *Quarterly Journal of Economics*, 124(2), 843–881.

GOLDIN, C., AND L. F. KATZ (2008): "Long-Run Changes in the Wage Structure: Narrowing, Widening, Polarizing," *Brookings Papers on Economic Activity*, 38(2007-2), 135–165.

GOOS, M., AND A. MANNING (2007): "Lousy and Lovely Jobs: The Rising Polarization of Work in Britain," *Review of Economics and Statistics*, 89(1), 118–133.

GOOS, M., A. MANNING, AND A. SALOMONS (2009): "Job Polarization in Europe," *American Economic Review*, 99(2), 58–63.

JUHN, C. (1999): "Wage Inequality and Demand for Skill: Evidence from Five Decades," *Industrial and Labor Relations Review*, 52(3), 424–443.

JUHN, C., AND K. M. MURPHY (1995): "Inequality in Labor Market Outcomes: Contrasting the 1980s and Earlier Decades," *FRBNY Economic Policy Review*, 1(1), 26–32.

KATZ, L. F., AND K. M. MURPHY (1992): "Changes in Relative Wages, 1963-1987: Supply and Demand Factors," *The Quarterly Journal of Economics*, 107(1), 35–78.

KING, M., S. RUGGLES, J. T. ALEXANDER, S. FLOOD, K. GENADEK, M. B. SCHROEDER, B. TRAMPE, AND R. VICK (2010): *Integrated Public Use Microdata Series, Current Population Survey: Version 3.0*. Minnesota Population Center, Minneapolis, MN.

LEMIEUX, T. (2006): "Postsecondary Education and Increasing Wage Inequality," *American Economic Review*, 96(2), 195–199.

MEYER, P. B., AND A. M. OSBORNE (2005): "Proposed Category System for 1960-2000 Census Occupations," Working Paper 383, U.S. Bureau of Labor Statistics.

RUGGLES, S., M. SOBEK, T. ALEXANDER, C. A. FITCH, R. GOEKEN, P. K. HALL, M. KING, AND C. RONNANDER (2008): *Integrated Public Use Microdata Series: Version 4.0*. Minnesota Population Center, Minneapolis, MN.

SCOPP, T. S. (2003): "The Relationship Between the 1990 Census and Census 2000 Industry and Occupation Classification Systems," Technical Paper 65, U.S. Census Bureau.

U.S. CENSUS BUREAU (1989): "The Relationship Between the 1970 and 1980 Industry and Occupation Classification Systems," Technical Paper 59.

Figure 1: Smoothed Changes in Employment by Occupation, 1980-2000 (Occupations Ranked by Average Years of Schooling)

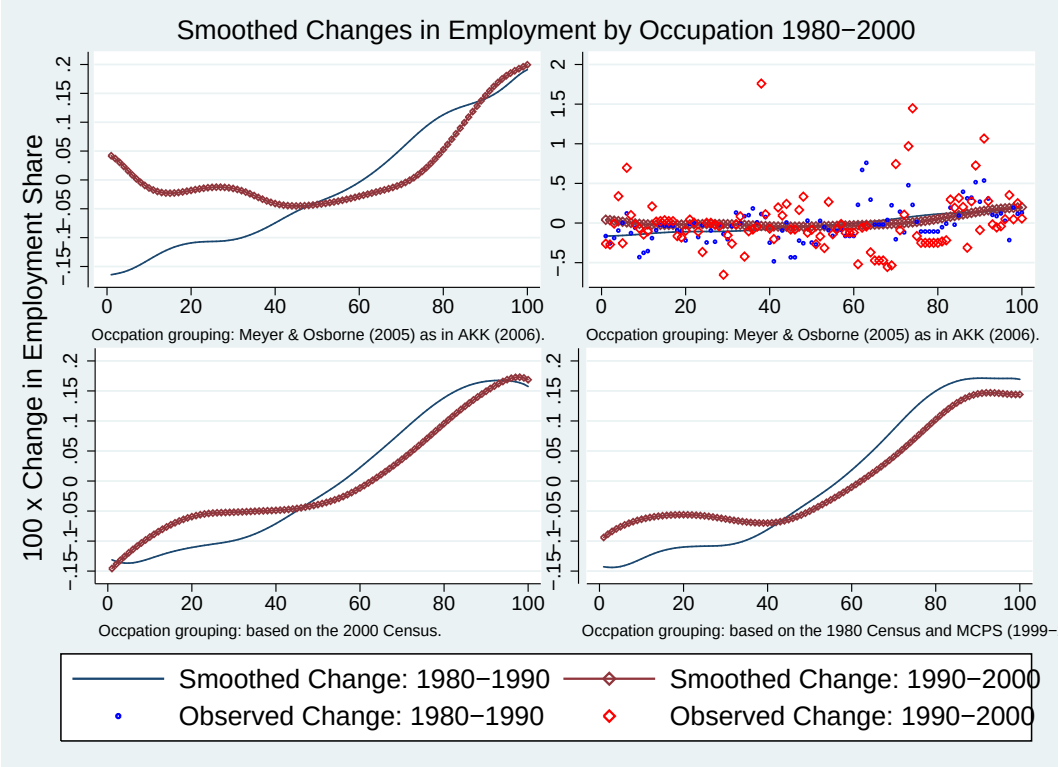


Figure 2: Employment Changes by Job Skill Decile and Decade

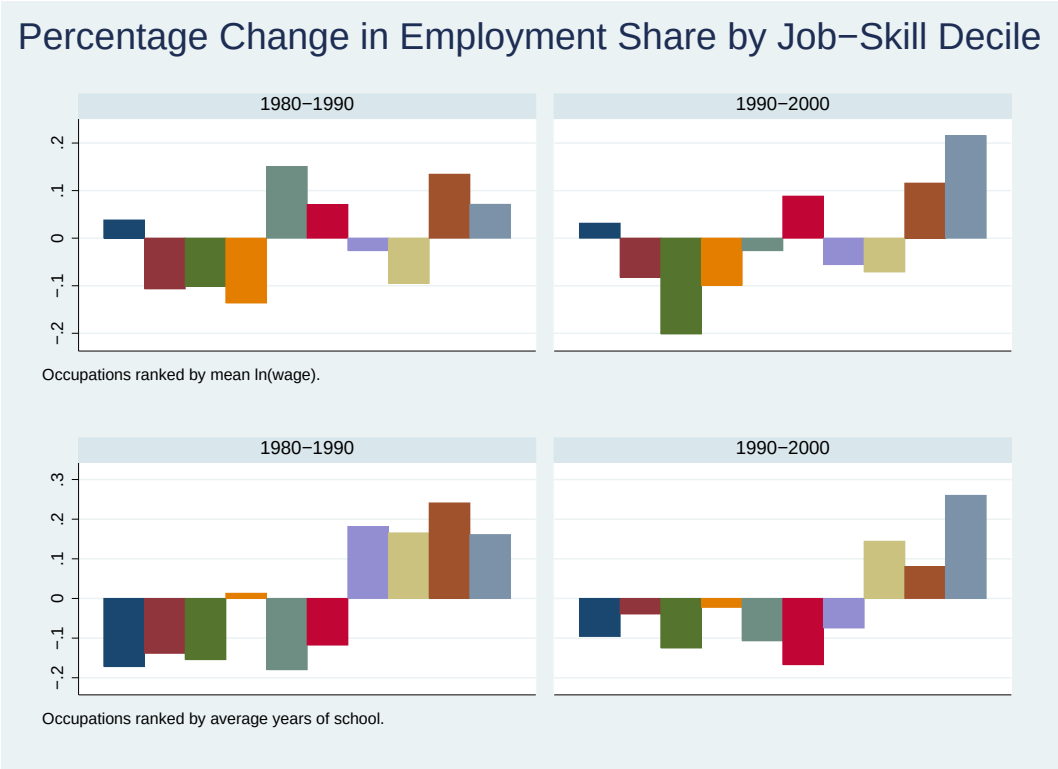


Figure 3: Employment Changes by Job Skill Decile

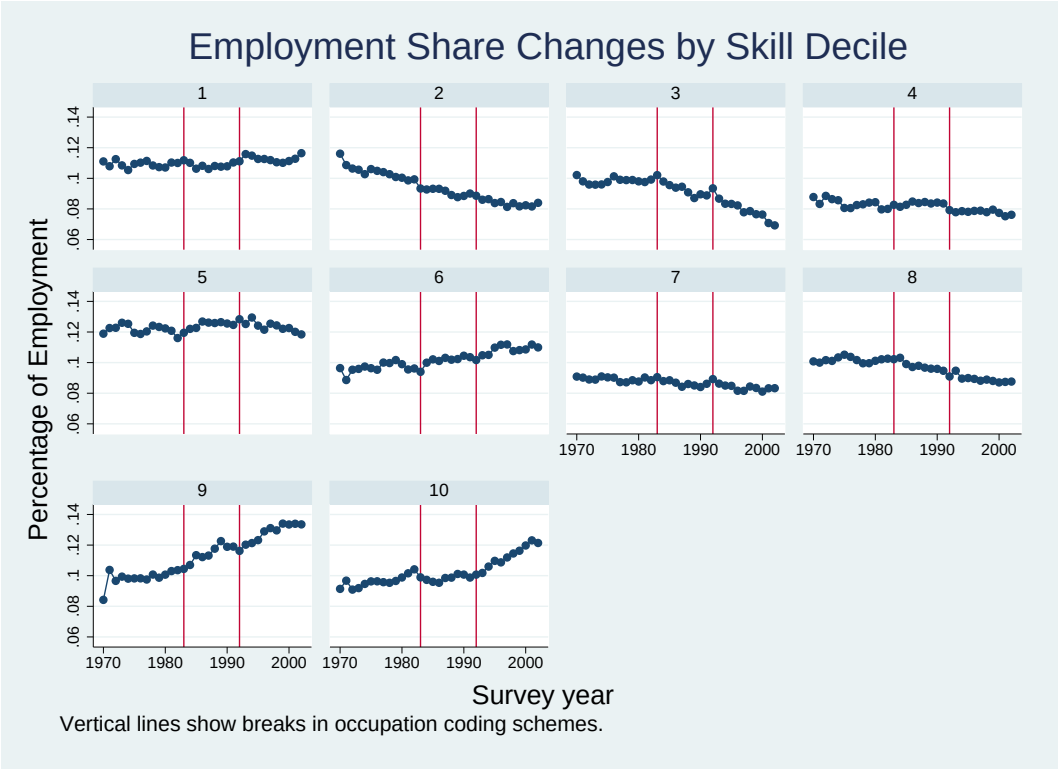


Figure 4: Employment Changes by Major Occupation Group